On Studying the Inter-Relationship amongst Sustainable Building Information Modelling (SBIM) Practices Indicators in Construction Projects

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ABSTRACT
In recent years, there have been significant calls for a more technologically driven construction sector which would not meet the expected standards in quality, time and cost but also integrate sustainable principles in delivering its final products. This research study aims at determining and prioritizing the key criteria success factors (CSFs) that can enhance the integration of Building Information Modelling (BIM) and sustainable practices in construction projects. The implementation of these key drivers would help the construction sector to implement sustainable practices and BIM. After the exploration , these key drivers are further studied for establishing the possible inter-relationships amongst them using ISM methodology .

Keywords
Sustainable building information modeling, ISM Methodology ; construction industry

1. INTRODUCTION
The construction industry is a robust and complex environment wherein projects involving several processes and activities often take place simultaneously. In recent years, several technology tools and systems have been integrated to improve the design and construction of projects. Several innovative approaches , techniques and concepts have been introduced and revived from past in recent years . Approaches such as BIM technologies, cloud-based project management, augmented reality and visual reality, sustainability, mobile technology, Radio Frequency Identification (RFID) and sensors for tracking and measurement and other collaborative solutions have been given chance to proliferate. Building information modelling (*a.k.a* BIM) has continued to gain relevance and significance in the AEC industry and was described by extant literature [1-4] as an innovative digital technology. More so, BIM can be used throughout various stages of project development from the planning and design stage, through the construction phase, facility management to demolition . Its capacity of easing the dissemination of project information could enhance the success of projects [4-5] as well as help the clients to derive good returns on their investment [6-7].

1.1 Concept of sustainability & BIM
The activities and processes involved in the construction projects and in the construction sector have significant impact on the ecosystem [6] More so, it is difficult to separate sustainable urban planning and the construction industry because they are closely related [9-10] and involved the application of modern technology, software and tools (like BIM) [1-4]. Extant literature such as [1-5] described the construction industry as that which requires collaboration among the project stakeholders and the coordination of the processes as well as could yield higher return on investment [5].

Further [11] outlined the challenges faced in achieving sustainable development. BIM is described as a "digital technology" [12] which could improve the efficiency of delivering construction projects. Meanwhile, sustainability is related to the lifecycle of facilities [13] and involves assessing the environmental, social and economic constructs of sustainable development. However, most studies on sustainability issues have centered around environmental sustainability [4-5]. Several other studies have been conducted to exemplify how BIM was implemented to enhance sustainability in the built environment. [13] designed a prototype system linked with a BIM software to appraise steel structures designs for sustainability criteria. The basis of the model assessment developed by [13] is to evaluate for the cost, carbon and ecological footprint which are important sustainability measures. They recommended for project stakeholders to be aware of sustainable design solutions and alternatives suitable for projects. There are still challenges facing the construction industry in undertaking projects in a responsible and sustainable manner due to what they term lack of "key drivers of urbanization". The objectives of the research is therefore many folds *i.e.* to first (i) identify the drivers (CSFs) of integrating BIM and sustainable practices; and (ii) thereafter prioritizing such factors based on the level of importance.

The paper is organised as follows : Section2 deals with critical success factors of integrating BIM and sustainability principles at the design stage of construction projects . Section 3 deals with ISM methodology . Section 4 with case example . Section 5 with managerial implications .

2. LITERATURE REVIEW
Critical success factors of integrating BIM and sustainability principles at the design stage of construction projects. The authors have followed the research work of [3] in identifying the criteria . Primary reason being that they have taken the views of invited experts having extensive experience in construction industry . They have interviewed the experts .The invited experts are those who have satisfied at least two of the following criteria : 1) Experts with extensive experience in the construction industry ; 2) experts who have participated in current and recent projects on both BIM and sustainability practices in the AEC industry and 3) experts with sound knowledge and understanding of the concepts of BIM and sustainability practice .

Category	Code	CSFs	Reference
Information and awareness [I&A]	C1	Information and knowledge sharing within the industry [IKS]	[14-15]
	C2	Greater awareness and experience level within the firm [GAEL]	[4]
	C3	More training programs for cross field specialists in BIM and sustainability and increased research in industry and academia [TPS]	[14]
Funding and cost Budget [FCB]	C4	Govt. establishment for start-up funding for construction firms to kick start BIM initiatives [GE]	10
	C5	Adequate construction cost allocated to BIM and availability of Availability of financial resources for BIM software , licenses and its regular upgrades[AFR]	[14]
Legal framework and legislation [LFL]	C6	Establishments of BIM standards , codes , rules and regulations / Establishment of a model of good practice for BIM and sustainability implementation [EBS]	[14]
	C7	Security of intellectual property and rights [SIPR]	11 , 17
	C8	Appropriate legislation and governmental enforcement and credit for innovative performance [ALGE]	[14]
	C9	Ease in obtaining building plan approvals and construction permits [EBPA]	[15]
Managing project teams [MPT]	C10	Shared risks , liability and rewards among project stakeholders [SRLR]	[15,17]
	C11	Effective collaboration and co-ordination amongst project participants [ECC]	[14]
	C12	Clarity in client requirements and ownership and measures for achieving sustainable projects [CCRO]	[18,21]
	C14	Early involvement of project teams [EIT]	[21]
	C15	Client satisfaction level on BIM projects [CSL]	[21]
	C16	Supportive organization culture and effective leadership [SOC]	6
Technical competence and software development [TCSD]	C17	Technical competence of staff [TCS]/experienced staff	[4]
	C18	Availability and affordability of cloud based technology [ACBT]	[14]
	C19	Availability of BIM and sustainability databases [ASD]	[14,21]
Design / construction design and innovation capabilities	C20	Better design products / multi- design alternatives [BDP/MDA]	[21,18]
	C21	Real time sustainable design [RTSD]	[18]
	C22	Improved project related decision making [IPRDM]/improved innovative capabilities [IIC]	[18,19]
	C23	Facilitating the implementation of green building practices [IGBP]	[21-22]
	C24	Integration of sustainable strategies with business planning [ISS]	[18,19]
	C25	Appropriate selection of sustainable materials [ASSM]	[14,18,19]
	C26	Reduced site based conflicts [RSC]	[18-19] [14]
Safety risks and conflicts	C27	Reduction of material wastage [RMW]	[19]
	C28	Reduction in safety risks [RSR]	[14]

[Adapted primarily from [1-3,15]

3. INTERPRETIVE STRUCTURAL MODELLING METHODOLOGY

Suggested by Warfield [26], ISM works with the following steps: It starts with identifying the relevant elements and pair-wise establishing the contextual relationship amongst them. Thereafter, a structural self-interaction matrix (SSIM) may be developed between two variables i.e. *i and j* establishing a "Lead to" relationship between criteria. Four symbols *viz.* V, A , X & O are used for establishing the relationships. It further lead to developing initial reachability matrix and then a final reachability matrix after removing transitivity. Afterwards, the reachability set and antecedent set for each criterion and for each element can be obtained from the final reachability matrix. After that a level partition matrix can be obtained based on establishing the precedence relationships and arranging the elements in a topological order . A Mic-Mac analysis is performed categorizing the variables in to autonomous, dependent, driver and linkage category. Finally, a diagraph can be obtained.

4. CASE EXAMPLE

From the above section 2, 28 CSFs chosen are now further studied for the possible inter-relationships amongst them . These are Information and knowledge sharing within the industry [IKS]; Greater awareness and experience level within the firm [GAEL]; More training programs for cross field specialists in BIM and sustainability and increased research in industry and academia [TPS]; Govt. establishment for start-up funding for construction firms to kick start BIM initiatives [GE]; Adequate construction cost allocated to BIM and availability of financial resources for BIM software , licenses and its regular upgrades[AFR]; Establishments of BIM standards , codes , rules and regulations [EBS]; Security of intellectual property and rights [SIPR]; Development of appropriate legal framework for BIM [DALF]; Appropriate legislation and governmental enforcement and credit for innovative performance [ALGE]; Ease in obtaining building plan approvals and construction permits [EBPA]; Shared risks , liability and rewards among project stakeholders [SRLR] ; Effective collaboration and co-ordination amongst project participants [ECC]; Clarity in client requirements and ownership and measures for achieving sustainable projects [CCRO]; Client satisfaction level on BIM projects [CSL]; Supportive organization culture and effective leadership [SOC]; Technical competence of staff [TCS]; Availability and affordability of cloud based technology [ACBT]; Availability of BIM and sustainability databases [ASD] ; Better design products / multi- design alternatives [BDP/MDA] ; Real time sustainable design [RTSD] ; Improved project related decision making [IPRDM]/improved innovative capabilities [IIC]; Facilitating the implementation of green building practices [IGBP]; Integration of sustainable strategies with business planning [ISS]; Appropriate selection of sustainable materials [ASSM]; Reduced site based conflicts [RSC]; Reduction of material wastage [RMW]; Reduction in safety risks [RSR] which are further studied for possible inter-relationship amongst them using ISM methodology.

These CSF s have been identified through literature survey over search engines such as google scholar exploring published articles available in Research gate , academia.edu etc.

Fig 1: SSIM matrix for pair wise relationship amongst barriers

S.No.	Barriers	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
		IKS	GAEL	TPS	GE	AFR	EBS	SIPR	DALF	ALGE	EPBA	SRLR	ECC	CCRO	CSL	SOC	TCS	ACBT	ASD	BDP	RTSD	IIC	IGP	ISS	ASSM	RSC	RMW	RSR
1	IKS		X	X	A	A	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V
2	GAEL			V	A	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V
3	TPS				A	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V
4	GE					V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V
5	AFR						V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V
6	EBS							V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V

7	SIPR								V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V
8	DALF									V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V
9	ALGE										V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V
10	EPBA											V	V	V	X	X	X	X	V	V	V	V	V	V	V	V	V	V
11	SRLR												V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V
12	ECC													V	V	V	V	V	V	V	V	V	V	V	V	V	V	V
13	CCRO														V	V	V	V	V	V	V	V	V	V	V	V	V	V
14	CSL															V	V	V	V	V	V	V	V	V	V	V	V	V
15	SOC																V	V	V	V	V	V	V	V	V	V	V	V
16	TCS																	V	V	V	V	V	V	V	V	V	V	V
17	ACBT																		V	V	V	V	V	V	V	V	V	V
18	ASD																			V	V	V	V	V	V	V	V	V
19	BDP																				V	V	V	V	V	V	V	V
20	RTSD																					V	V	V	V	V	V	V
21	IIC																						V	V	V	V	V	V
22	IGBP																							V	V	V	V	V
2	IS																								V	V	V	V

3	S																											
24	ASSM																									V	V	V
25	RSC																										V	V
V 26	RMW																											V
27	RSR																											

Fig 2: Initial reachability matrix

S. No.	Barriers	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
		IKS	GAEL	TPS	GE	AFR	EBS	SIPR	DALF	ALGE	EPBA	SRLR	ECC	CCRO	CSL	SOC	TCS	ACBT	ASD	BDP	RTSD	IIC	IGP	ISS	ASSM	RSC	RMW	RSR
1	IKS	1	1	1	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
2	GAEL	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
3	TPS	1	0	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
4	GE	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
5	AFR	1	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
6	EBS	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
7	SIPR	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
8	DALF	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
9	ALGE	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
10	EPB	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

	A																											
11	**SRLR**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**
12	**ECC**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**
13	**CCRO**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**
14	**CSL**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**
15	**SOC**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**
16	**TCS**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**
17	**ACBT**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**
18	**ASD**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**
19	**BDP**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**
20	**RTSD**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**
21	**IIC**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**1**	**1**	**1**	**1**	**1**	**1**
22	**IGBP**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**1**	**1**	**1**	**1**	**1**
23	**ISS**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**		**1**	**1**	**1**	**1**	**1**
24	**ASSM**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**1**	**1**	**1**
25	**RSC**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**1**	**1**
V26	**RMW**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**1**
27	**RSR**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**

Fig 3 : Final reachability matrix

S. No.	Barriers	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	D.P
		IKS	GAEL	TPS	GE	AFR	EBS	SIPR	DALF	ALGE	EPBA	SRLR	ECC	CCRO	CSL	SOC	TCS	ACBT	ASD	BDP	RTSD	IIC	IGP	ISS	ASSM	RSC	RMW	RSR	
1	IKS	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	26
2	GAEL	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	26
3	TPS	1	0	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	25
4	GE	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	27
5	AFR	1	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	24
6	EBS	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	22
7	SIPR	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	21
8	DALF	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	20
9	ALGE	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	19
10	EPBA	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	18
11	SRLR	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	17
12	ECC	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	16
13	CCRO	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	15
14	CS	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	14

	L																												
15	**SOC**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**13**
16	**TCS**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**12**
17	**ACBT**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**11**
18	**ASD**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**10**
19	**BDP**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**9**
20	**RTSD**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**8**
21	**IIC**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**7**
22	**IGBP**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**1**	**1**	**1**	**1**	**1**	**6**
23	**ISS**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**		**1**	**1**	**1**	**1**	**1**	**5**
24	**ASSM**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**1**	**1**	**1**	**4**
25	**RSC**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**1**	**1**	**3**
V26	**RMW**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**1**	**2**
27	**RSR**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**1**
	De.P	**5**	**3**	**4**	**1**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	

D.P : Driving power ; De.P : dependence power

4.1 Level Partition

From the final reachability matrix, reachability and final antecedent set for each factor are found. The element for which the reachability and intersection sets are same are the top-level element in the ISM hierarchy. After the identification of top level element, it is separated out from the other elements and the process continues for next level of elements. Reachability set, antecedent set, intersection set along with different level for elements have been shown below in table 1.

Table 4.3.1: Iteration I

S. No.	**Reachability set**	**Antecedent set**	**Intersection set**	
1	27	1,2,3,4,5,6,7,8,9,10,11,1,21,3,1,4,1,5,,16,17,18,19,20,	27	I

		21,22,23,24,25,26,27		
2	26,27	1,2,3,4,5,6,7,8,9,10,1 1,1,21,3,1,4,1,5,,16,1 7,18,19, 20,21,22,23,24,25,26	26	II
3	25,26,27	1,2,3,4,5,6,7,8,9,10,1 1,12,13,14,15,16,17, 18,19,20,21,22, 23,24,25	25	III
4	24,25,26,27	1,2,3,4,5,6,7,8,9,10,1 1,1213,14,15,16,17,1 8,19,20,21, 22,23,24	24	IV
5	23,24,25,26,27	1,2,3,4,5,6,7,8,9,10,1 1,1213,14,15,16,17,1 8,19, 20,21,22,23	23	V
6	22,23,24,25, 26,27	1,2,3,4,5,6,7,8,9,10,1 1,12,13,14,15,16,17, 18,19,20,21,22	22	VI
7	21,22,23,24,25,26, 27	1,2,3,4,5,6,7,8,9,10,1 1,12,13,14,15,16,17, 18,19,20,21	21	VII
8	20,21,22,23,24, 25,26,27	1,2,3,4,5,6,7,8,9,10,1 1,12,13,14,15,16,17, 18,19,20	20	VIII
9	19,20,21,22,23,24, 25,26,27	1,2,3,4,5,6,7,8,9,10,1 1,12,13,14,15,16,17, 18,19	19	IX
10	18,19,20,21,22,23, 24, 25,26,27	1,2,3,4,5,6,7,8,9,10,1 1,12,13,14,15,16,17, 18	18	X
11	17,18,19,20,21,22, 23,24, 25,26,27	1,2,3,4,5,6,7,8,9,10,1 1,12,13,14,15,16,17	17	XI
	…….	……	…..	
16	6,7,8,9,10,11,12,13 ,14,15,16,17,18,19, 20,21,22,23,24,25, 26,27	1,2,3,4,5,6	6	XVI
17	1,5,6,7,8,9,10,11,1 2,13,14,15,16,17,1 8,19,20,21,22,23,2 4,25,26,27	1,2,3,4,5	1,5	XVI I
18	1,3,5,6,7,8,9,10,11, 12,13,14,15,16,17, 18,19,20,21,22,23, 24,25,26,27	2,3,4	3	XVI II
19	1,2,3,5,6,7,8,9,10,1 1,12,13,14,15,16,1 7,18,19,20,21,22,2 3,24,25,26,27	2,4	2	XIX
20	1,2,3,4,5,6,7,8,9,10 ,11,12,13,14,15,16, 17,18,19,20,21,22, 23,24,25,26, 27	4	4	XX

5. CONCLUSIONS

There have been increased in research in BIM and sustainability studies in recent years. However, only a few studies had attempted to investigate the integration of BIM technologies to amplify the implementation of sustainability practices in the construction industry. Conclusively, further research works can dwell on using BIM and other innovative technologies (such as RFID, GIS, etc.) to amplify the execution of sustainable principles and the three pillars of sustainability – economic, social and environmental technologies in the built environment towards ensuring a sustainable urban development.

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